The Australian National University
Institute of the Arts

Canberra School of Art
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REPORT

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1.1 Addressing the problems - Post-Graduate Studies proposal

Overall Objectives

* to design and make objects that are largely concerned with utilitarian function, and, that not only pertain to this 'traditional' criteria, but also remain visually stimulating. Objects that are an expression of my creativity with the investigation of

colour - how colour works with an object to give it a dramatic, sensual or funky quality

dynamics - how a combination of shapes and forms work on different axes to give an object a sense of speed or lift. Using dynamics in my design as a direct extension of the drawing process

* to develop my skills as a silversmith, continuing those techniques already learnt, and amalgamating these with alternative techniques.

Concepts I wish to explore

I would like to address the problems within my own work. This will involve investigation of the forementioned, colour, dynamics and utilitarian functionality.

I would like to make a piece or set of pieces, and then analyse it in terms of these problems before continuing with the next. This will allow me to improve on and understand with greater clarity my creative processes, style, and direction in my work.

How I wish to develop the proposal

I intend to undertake a full year's quota of advanced life drawing to keep myself informed with

* gesture in my drawing which will indirectly extend into my designs
* form; how a shape or object balances physically and visually, and the spaces that are created through its presence.

Taking into account that the fourth year of my degree was primarily involved with the making of teapots, and coffee pots, I believe it would be of great benefit to myself as a craftsperson to continue with the making of such vessels with the addition of other components where appropriate.

Resources necessary

I believe that the Gold & Silversmithing Workshop has all the necessary equipment for the development of my Post-graduate objectives. In the first few weeks of the year, I hope to be tutored by an external consultant to assist in the welding of aluminium. Also, I intend to be working primarily under the supervision of Ragnar Hansen.

1.2 Post-Graduate Studies Programme

Overall objectives

To design and make objects primarily concerned with utilitarian function. In pertaining to this criteria, the pieces will have to function well in the physical sense: that is, in their ability to be handled, user-friendly, and cleanable (in their practicality).

Throughout the course of the year, I wish to further develop my understanding of teapots, in this utilitarian sense, visually and in the process of designing and making such pieces. Furthermore, I wish to focus on the making of aluminium

teapots, as I believe this material has many advantages in producing an object that is functional. It is a very workable metal that is lightweight, can be coloured, does not tarnish, and does not have the financial connotations of silver.
I aim to develop my skills as a silversmith, continuing those techniques already learnt, and amalgamating these with new techniques. As aluminium cannot be soldered, it is necessary for me to learn techniques of welding and mechanically joining the material.

By the end of my post-graduate studies I aim to have completed a substantial, cohesive body of work which addresses the issues formentioned, and shows progress to a resolved piece or pieces of work.

Concepts I wish to explore

Aside from investigating utilitarian function within teapots, I will address and aim to solve other problems within my work. This will involve research into the use of colour, so that it does not become an overwhelming property of a piece, but remains an essential and dynamic element.

The juxtaposition and combination of three-dimensional shapes has been a very important aspect of my work. I will continue to explore these elements with the use of colour to accentuate these juxtapositions.

How I wish to develop the proposal

I have begun the programme by constructing an aluminium teapot both mechanically and by welding. The welding has already proven to be difficult and will require much practice and research through making, to understand its limitations and advantages. It has become apparent that I will have to manipulate my method of designing to suit the new construction techniques and limitations.

By documenting my research on the making processes, I will have a reference and guide not only for myself, but also for potential future students investigating aluminium welding.

On the completion of each piece, I will thoroughly analyse and document its success or failure, both visually and in terms of utilitarian function.

Time frame

It is difficult to estimate how long it will take me to master the welding of aluminium, though I imagine that by the fourth month of exploration and research into this technique, I will be able to direct my attention more toward the function, design and colour of the teapots.

Resources necessary

I believe that the Gold & Silversmithing Workshop has all the necessary equipment for the development of my post-graduate objectives. I will be working under the supervision of Ragnar Hansen and expect that this will prove to be a very successful partnership.

1.3 Post-graduate Introduction

In many ways, my post-graduate studies have been an expression of my need as an artist/craftsperson to research. It has been a period of both technical and theoretical research and also research into my understanding of what holloware design can be. Where do I stand with issues such as functionality and decoration? Where do my priorities lie when making sometimes seemingly simple decisions on my own designs, or developing ethics or personal principles of design?

In beginning my studies, the context of my work was mainly comparatory to my earlier work; improving on previous designs was one concern and always will be. Another was the assimilation and research of new techniques, materials and ideas into my designs and designing procedures. I had chosen to investigate Tungsten Inert Gas (TIG) welding of aluminium as my primary construction technique. This paper is the resulting documentation of ideas and techniques learned, largely through experience.

To choose aluminium as a primary material for making, was not a difficult decision. Its ability to be coloured through anodizing, its workability and its affordability put this metal into a category that is favourable and quite unlike any other.

Almost without exception I have used colour in my work; previously though, it had always been as an addition to the pieces as a whole, for example, as a handle or a lid. TIG welding gave me the opportunity to make pieces almost entirely in the one material. This gave me many new exciting and challenging options for use of colour.

To describe my work in terms of historical, cultural and theoretical background is difficult, however, the fact that it is part of a craft genre, facilitates viewpoints on form and function which are likely to be compared to movements such as the Bauhaus and Memphis. My work does not belong to either of these philosophies, but without question runs paralell to both. They each raise questions on what functions design should perform.

The Bauhaus derived the design of an object from its natural functions and relationships. Form followed function. 'It (the object) must serve its purpose usefully, be durable and economical'. Design was limited to characteristic geometric forms which aligned themselves to simple, cost-effective production. The Modernists saw the matching as saviour, making 'good' products for the masses. Decoration was cast aside as an unnecessary and undesirable characteristic pertaining to primitive design (Edward Loos; 1908).

Memphis denied and challenged the Modernist theories of form following function and total rationality. Rather, it attempted to produce objects that were consumable, elusive and infinitely desirable. The object became a fetish, ceasing to show its use value by declaring that only effects were necessary. These effects were largely concerned with decoration, ornament and colour. The important thing here is that the ornament, colour and decoration that Modernism has denied, in Memphis has taken an integral part of the form of an object. They now not only function as surface elements, but become functional in the form as a handle or spout. Structure and decoration became unified.

My work is a combination of both Modernist and Post-Modernist ideas. When designing a piece, I aim for vitality. There is no reason why a teapot that functions well cannot be ornamental in many ways. I agree to the Bauhaus's alignment with function, but find that its exclusion of ornament is irrelevant to contempory silversmithing.

I believe in the object as fetish with its effect value. My designs are one-off explorations into dynamics and form using contrasts between organic and machine-like parts: shapes that suggest movement within the piece, and colour which sets off this movement. They are austere in their precise quality, yet human in the way they present themselves.

My work requires that the viewer considers their concept of what a teapot is. It is no longer such a simple thing to be left by the kettle or placed unceremoniously on the table. It can be a centre-piece, fragile, machine-like, dangerous, exciting and curious. It is an object of art and craft.

2 NOTES ON ALUMINIUM AND WELDING

For an alternative to other methods of joining aluminium, welding offers many advantages for one-off and small production holloware pieces.

1. It is a relatively simple way to make air and water tight joins.
2. Welding can accommodate material thicknesses from very thin to thick.
3. The finish of a weld join can be to a very high standard, allowing for pieces made of several components to have a unified appearance.

2.1 Properties of aluminium.

1. Density : Aluminium's density is approximately one third that of steel. It is the lightest of all commonly used metals.
2. Thermal conductivity : Aluminium is a very good conductor of heat. Its thermal conductivity is about half that of copper and four times that of steel. This means that aluminium requires for welding, a heat input four times as rapid as is required for steel, for any given temperature increase. For this reason, if welding occurs too slowly, the work piece runs the risk of over-heating, causing deformities.
3. Coefficient of linear expansion : This measure of change of length in a material with change of temperature, shows aluminium to have an expansion coefficient approximately twice that of steel. This, combined with aluminiums high conductivity of heat, can make welding quite difficult with warpage. To prevent warpage it is necessary to weld quickly and to "tack" the join in several spots before welding.
4. Chemical properties : In all forms, aluminium is covered in an oxide film which is hard , tenacious and melts at a very high temperature (2050°c). It forms instantaneously on the metal surface, and, if removed, will reform instantly on exposure to the atmosphere. It is this property that makes aluminium highly corrosion resistant, but also impossible to solder, braise or weld without devices that remove the oxide while the join is being made and until the join is completely formed.

For these reasons, the following factors must be considered before welding aluminium. An intense, localised heat source must be used to overcome the adverse thermal characteristics of the metal. The oxide layer must be removed and prevented from recurring until the weld has formed. Welding must be quick to prevent tendencies of distortion.

There are several methods for welding aluminium. These include --

Arc welding - Tungsten-Inert-Gas (TIG); Metal-Inert-Gas (MIG); Pulse Arc; Stud; Atomic Hydrogen; Carbon Arc and Metal Arc.

Gas welding - Oxy-acetalyne; Oxy-hydrogen etc.

Resistance welding - Spot; seam; flash; butt; projection and percussion.

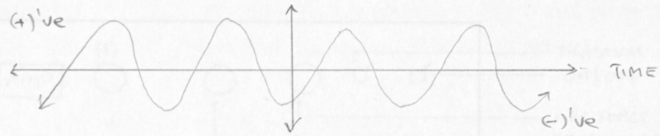
Specialised welding processes - Pressure; ultrasonic; friction; thermit; induction; high-frequency; electron beam; laser beam and plasma arc (Ronald Sinclair & Assoc, 1968: 51).

2.2 Tungsten - Inert - Gas welding

Tungsten-Inert-Gas (TIG) welding uses heat from an alternating current (a.c.) electric arc struck between the work and a non-consumable tungsten electrode. This arc is protected by a stream of inert gas (usually pure argon) which prevents reformation of surface oxide broken up by the arc.

The reason for having a tungsten electrode is for its high melting point and its stable, non-consumable properties. this allows for it to heat up to the very high temperatures necessary for welding, without displacing any oxides or impurities into the metal being welded. Inert gas is used to shield the metal being welded from oxidation after the oxide layer has already broken up, by preventing oxygen from coming into contact with the welded join until it has formed. Argon gas 99.9% pure is used except in special circumstances where it is mixed with helium to allow for better penetration when welding very thick material.

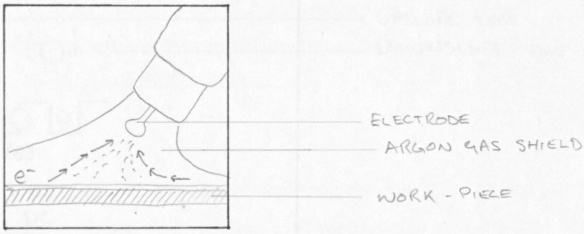
It is necessary to break up the oxide layer and the piece being welded for several reasons. Aluminium oxide has a higher melting point than aluminium. Therefore, if welding with excessive aluminium oxide on the surface, the piece may not look hot enough when really the core is molten under a still solid aluminium oxide surface. Secondly, aluminium oxide prevents a weld from penetrating evenly; not only will this cause a structurally weak weld, but will also cause uneven anodising etching and colouring.
For these reasons, when TIG welding, it is necessary to use an alternating current . This means that rather than having a direct current where electrons flow evenly from the electrode, through the piece and then completing the circuit, the current alternates to and from the electrode and the work-piece.



Sin Wave : a.c. changes polarity 100 -120 times per second

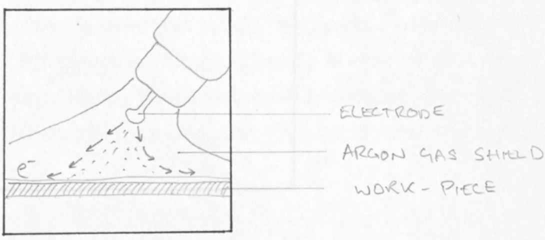
Whilst the current is on the positive side of the square wave, the electrons travel toward the electrode. This is the cleaning mode of the alternating current, as surface oxides are brokenup and removed by the shroud gas.

a.c. positive.



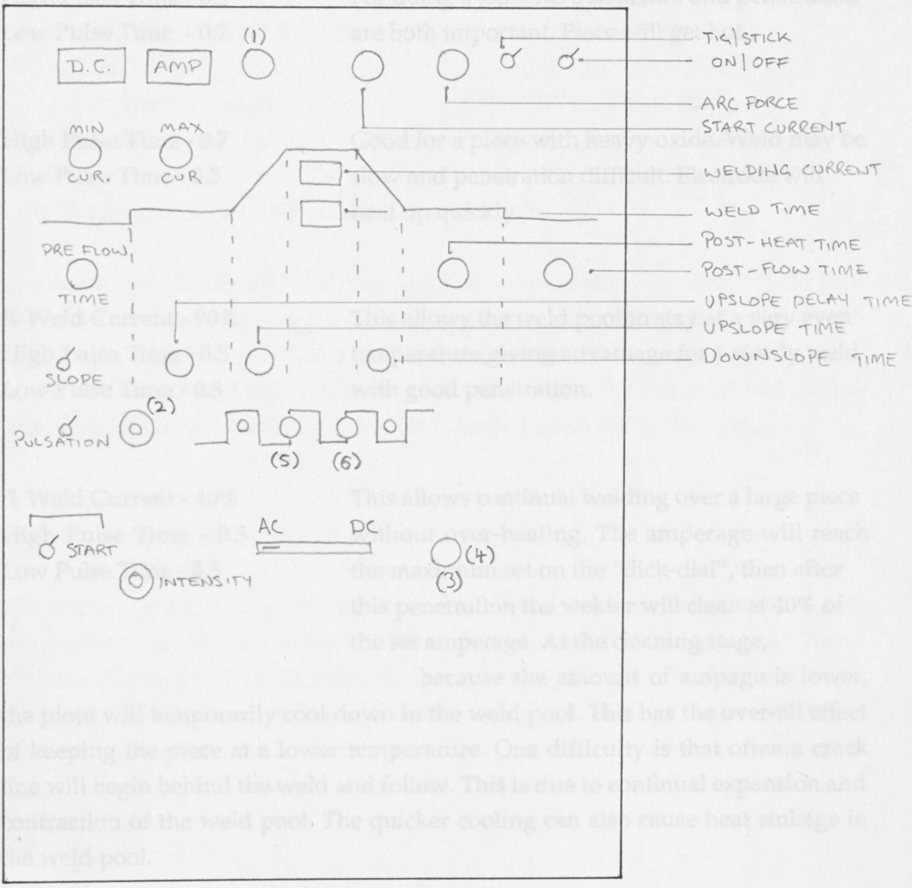
Whilst the current is on the negative side of the square wave, the electrons travel toward the piece. This is the penetrating mode, as heat builds up on the piece being welded allowing for weld penetration.

a.c. negative



On the "Hobart" cyber-wave welder, there are six main ways to alter the ratio of positive to negative.

* A C balance (1)
* % of weld current (2)
* max clean (3)
* max penetration (4)
* high pulse time (5)
* low pulse time (6)



A C balance - determines the position for the centre of the x axis up or down on the y axis. The higher on the y axis, the more cleaning.

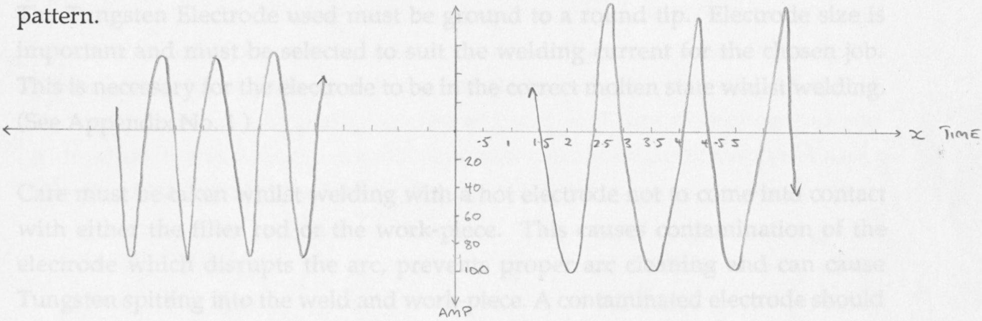
- % weld current - determines what amperage is reached on the cleaning mode as a percentage of the maximum amperage reached in the penetrating mode.

- Maximum clean / maximum penetration - Maximum clean mode is used when welding aluminium with heavy oxide. It allows a high ratio of cleaning to penetration. Maximum penetration can be used with most clean alloys, giving a higher ratio of penetration to cleaning.

High Pulse Time - 0.3 Low Pulse Time - 0.7	For doing a job where structure and penetration are both important. Piece will get hot.
High Pulse Time - 0.7 Low Pulse Time - 0.3	Good for a piece with heavy oxide. Weld may be slow and penetration difficult. Electrode will heat up quickly.
% Weld Current - 90% High Pulse Time - 0.5 Low Pulse Time - 0.5	This allows the weld pool to stay at a very even temperature giving advantage for a steady weld with good penetration.
% Weld Current - 40% High Pulse Time - 0.5 Low Pulse Time - 0.5	This allows continual welding over a large piece without over-heating. The amperage will reach the maximum set on the "flick-dial", then after this penetration the welder will clean at 40% of the set amperage. At the cleaning stage,

because the amount of ampage is lower, the piece will temporarily cool down in the weld pool. This has the over-all effect of keeping the piece at a lower temperature. One difficulty is that often a crack line will begin behind the weld and follow. This is due to continual expansion and contraction of the weld pool. The quicker cooling can also cause heat sinkage in the weld pool.

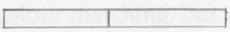
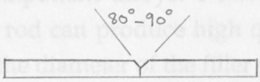
- Pulsation on / off - Only with pulsation **ON** can you adjust high-pulse, low-pulse and percentage weld current. If off, the machine has a standard cyber-wave pattern.



A.	Pulsation : on	B.	Pulsation : on
	% weld current : 50%		% weld current : 90%
	High Pulse Time : 0.5		High Pulse Time : 1.0
	Low Pulse Time : 0.5		Low Pulse Time : 0.5
	Amperage : 100 Amps		Amperage : 100 Amps

2.3 Joint Preparation and Procedures for TIG welding

Any weld used when TIG welding aluminium is carried out with a "butt join" where the two sections to be jointed are placed flush with each other.
Any weld where both material thicknesses are less than four mm, a flat butt-join is used. Where either material used is greater than 4mm, the but must be bevelled to ensure greater penetration. The bevel is angled between 80-90 degrees.

Butt join.  Bevel. 

Where metal has been filed or worked, all burrs must be removed to prevent weld contamination and to allow for a smooth even flow. Any tools used (eg.scraper,wire-brush or files) should be used exclusively for aluminium.
Cleanliness is imperative. There can be no dirt, oil or grease present on the weld location. The surface can be wire brushed and cleaned with acetone or methanol. The filler metal, work table and operator's gloves must also be clean.

2.4 Tungsten Electrode

The Tungsten Electrode used must be ground to a round tip. Electrode size is important and must be selected to suit the welding current for the chosen job. This is necessary for the electrode to be in the correct molten state whilst welding. (See Appendix No. 1)

Care must be taken whilst welding with a hot electrode not to come into contact with either the filler rod or the work-piece. This causes contamination of the electrode which disrupts the arc, prevents proper arc cleaning and can cause Tungsten spitting into the weld and work-piece. A contaminated electrode should be cleaned by re-grinding.

As a general rule, if the weld bead is larger than the electrode, the electrode is overloaded. However, as shown in Appendix No. 1, a zirconated electrode increases the melting point of the electrode and therefore decreases the size of the electrode needed for any given amperage. This allows for greater access when welding in confined areas.

2.5 Filler Rod

Although in some cases joins may be made without the use of filler rod, I have found it necessary in welding all of my pieces. Filler rod can be purchased to match alloys being welded with the addition of higher quantities of silicon and/or magnesium (See Appendix No. 2). A filler rod of the original material can be made and used, identically matching component alloys. I have used both techniques. Over-alloyed, purchased filler rod can produce high quality welds and good colour matching, but is limited to the diameter of the filler wire which is often very thin and inappropriate without a feeding gun. Filler rod made from the parent metal does not allow for such smooth welding but is not limited by size. It also colour matches very well.

Filler rod should be the same thickness as the material to be welded and should also be cleaned thoroughly.

Caustic soda may be used for etching off greases and oxide present on the rod. Purchased filler wire need not be cleaned in caustic.

2.6 Welding Current

It is suggested in the 'ESAB Advanced aluminium welding video' that 40 amps per mm of plate thickness is used for correct welding penetration. I have found that for a 3mm aluminium weld join where 120 amps are recommended, that 70 amps were enough. Amperage can be adjusted with use of foot control and welder dials. In this way you may set your maximum welding current at 40 Amps but weld at 20 Amps by decelerating on the foot control.

2.7 Welding Technique

When welding, the filler rod is held in the left hand and the torch in the right. The torch is held at a 45 degree angle to the work-piece and is mirrored by the filler rod which is also held at this angle. The end of the filler rod where higher temperatures are reached, should always be held within the Argon Gas Shield. The electrodes should protrude no more than 5 mm from the torch shroud. As the electrode protrudes, the pressure of Argon gas needed increases. Normally the amount of gas needed is no more than 15 litres per minute (15 LPM). The arc between the work-piece and the electrode should be kept as short as possible, ideally leaving just enough space for the filler rod.
Pieces to be welded are held in a secure position on the work-table with good contact. If there is not good contact between the work table and the aluminium to be welded, upon welding, an arc will jump either from the work-table to any section of the metal being welded which has a gap from .5 to 5 mm, or will arc from the electrode from the point on the aluminium where good contact is being made. This can cause burnt dust inclusions deep into the aluminium, tungsten spitting or electrode meltdown.
It is also necessary to tack pieces being welded together. This helps to prevent shifting of pieces and warpage. It can also be used as a method for pre-heating the work-piece. Tacking (or nesting) should occur at approximately 5 to 10cm intervals, depending on work size and thickness.
To start welding, the foot control is pressed completely to the ground. On this, the shield gas begins to flow for a predetermined time before the arc is struck. Once the arc is struck the amperage can be lowered with the foot control.

Filler rod should not be used until penetration of the Aluminium occurs. This penetration where deep enough will leave a 'key-hole' formation. Without the presence of oxide, the molten metal will be mercury like in appearance. The weld bead is formed by placing the filler rod in the molten zone with a tapping or pecking gesture. The parent metal must melt before the next tap of the filler rod. Welding wherever possible should occur toward the operator. To achieve a good weld, comfort of the operator is essential, this requires that the work piece is set at the correct height for hand manouverability and visibility. It is also necessary to have the area to be welded as easily accessible as possible.

2.8 Pre-Heating

One common problem when welding aluminium is to achieve good penetration. This problem occurs when either too low an amperage is used or if weld speed is too fast for the given amperage. If good penetration does not occur, the weld bead will sit partly on the surface of the two metals that have been joined. The weld may actually look quite good, however, upon filling, either a crack will appear or the pieces will completely separate. One way to help overcome this problem is by pre-heating the pieces to be welded. This will mean that for any given amperage, the time and amperage needed to penetrate the metal can be greatly reduced. Depending on the size, shape and thickness of the pieces being welded, preheating can be done with torch flame, tacking or by using a kiln. Kiln preheating is preferable when welding larger pieces, as a uniform temperature (no more than 400°c) can be reached. If torch flame is used, temperatures required can be measured with 'Thermochalk'.
When welding larger pieces of work, as the piece heats up, amperage will have to be reduced gradually with the foot-control to prevent burning through with too high a temperature.

2.9 Anodizing Welded pieces

Anodizing is a commonly used industrial process that produces a stable crystal structure on the surface of aluminium. This greatly strengthens parts used in industry, for welding materials, hardware and houseware. The work-piece is attached to an aluminium connection and then immersed in an electrolytic solution (in our case sulphuric acid).

The piece then receives a positive charge whereby oxygen is released, building up a film on the surface of the metal. This film is made up of many pores, which, if anodized under correct conditions, can accept colour molecules in a dyeing process.

When aluminium is welded, its chemical and molecular properties are changed. This means that in the anodizing process, the welded areas will react differently. Most commonly, the welded area will accept more colour in the dyeing process, causing any seams to look darker.

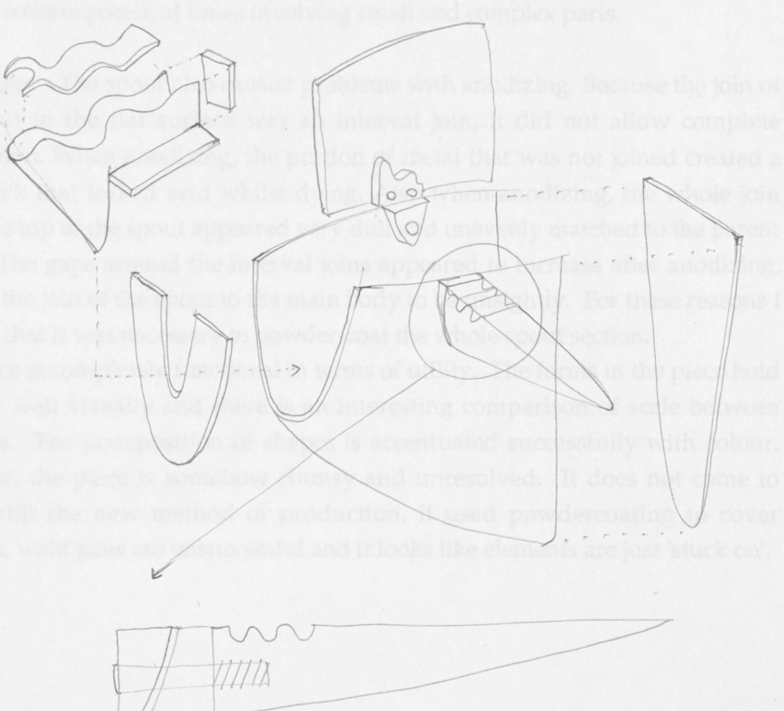
Other imperfections in weld joins may include
- porosity
- inclusions
- cracks.

These can cause bleaching during the anodizing process whereby acid contained in these faults will leak out during the dyeing or steaming stages. This is due to the high temperatures involved, expanding the metal and forcing out any contained acid.

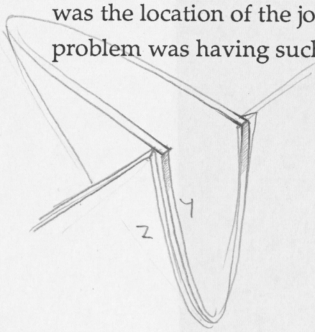
3 ANALYSIS OF WORKS

3.1 TEAPOT NUMBER 1.

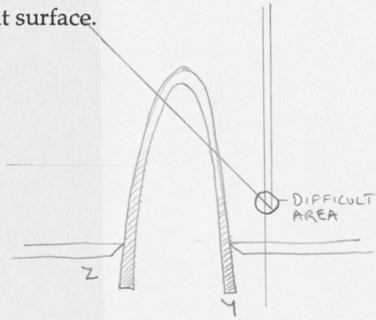
The first teapot made in my postgraduate studies was an exploration into what could and could not be done with welding. This teapot was designed similarly to those designed in the fourth year of my degree. Although I had an understanding of how aluminium worked when welding test pieces, I had little understanding of how the material and techniques would work on a complete, complex piece of work. I found that one of the main differences between soldering and welding was that with soldering, most joins are easily accessible.
When TIG welding, access to a join is restricted by sight, locality, size of the hand-piece and shroud, extension of the electrode from the shroud, and accessibility of the argon gas flow. When designing this piece, these factors were unable to be taken completely into consideration.



All joins in this piece were butt joins. The main problem when welding this piece was the location of the joins; particularly when joining the spout to the body. The problem was having such a steep angle penetrating a flat surface.



To allow for penetration it was necessary to file 'z' on an angle so that there would be space between it and 'y'. Without this penetration it would be impossible to have enough strength in the join. Another problem was that after filing enough clearance for penetration it was very difficult to heat up the two parent metals without 'blowing' out through the front.



The piece allowed for my first discovery of warpage. When welding z-y I 'tacked' the two pieces together at the corners. After making the first tack I obviously did not move quickly enough onto the second. By the time I had begun re-welding, the first tack had contracted and pulled the spout to the wrong angle. Apart from working quickly, this could have been avoided by pre-heating the pieces to be welded. Another difficulty was that there were so many joins and that almost all of them were exposed, at times involving small and complex parts.

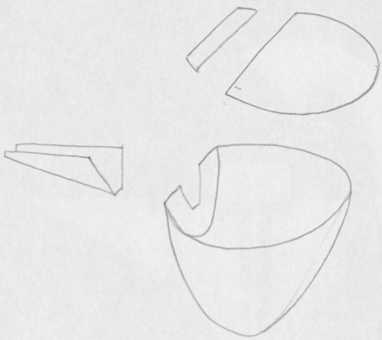
<u>Anodizing</u>: - The spout also caused problems with anodizing. Because the join of the spout to the flat surface was an interval join, it did not allow complete penetration. When anodizing, the portion of metal that was not joined created a gap/crack that leaked acid whilst dying. Also when anodizing, the whole join along the top of the spout appeared very dull and unevenly matched to the parent metal. The gaps around the interval joins appeared to increase after anodizing, causing the join of the spout to the main body to be unsightly. For these reasons I decided that it was necessary to powder-coat the whole spout section.

This piece is completely functional in terms of utility. The forms in the piece hold together well visually and there is an interesting comparison of scale between elements. The juxtaposition of shapes is accentuated successfully with colour. However, the piece is somehow clumsy and unresolved. It does not come to terms with the new method of production, it used powdercoating to cover mistakes, weld joins are unsuccessful and it looks like elements are just 'stuck on'.

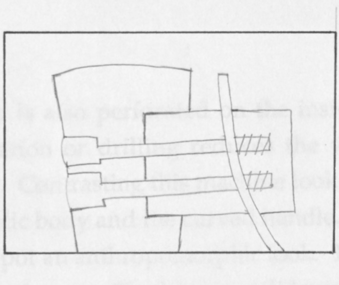
Teapot Number 1.
Aside from the negative points, this piece was a necessary starting point from which problems were able to be viewed, discussed and improved upon.

3.2 TEAPOT NUMBER 2.

The main problem with this teapot addressed concerning the first, was the number of weld joins. The main vessel of the piece has two flat sections welded across the top. The only other welds occur on the spout.

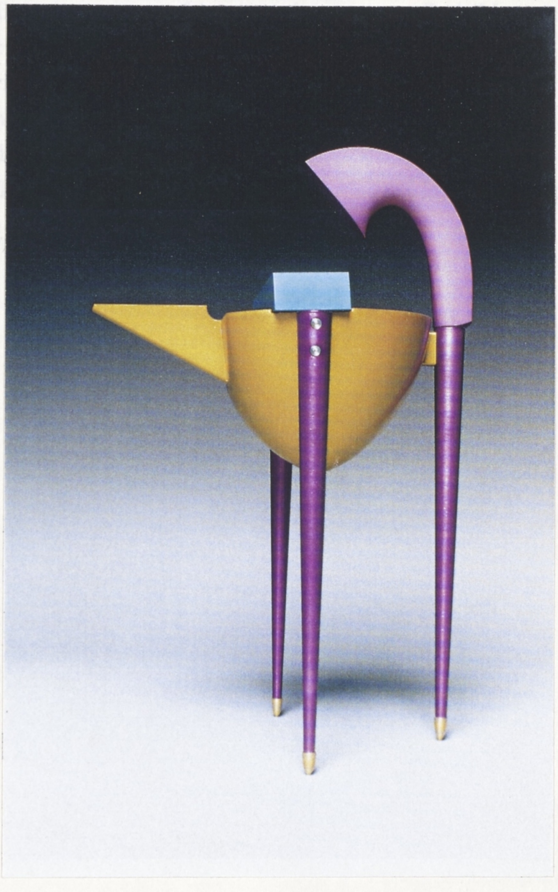


All weld joins were of better quality than in the first piece though similar problems did occur. Welding showed inconsistent colour after anodizing. Around the weld joins, the colour varies from being darker than the overall piece to being lighter. This again is due to molecular and chemical variations in the metal. During the welding process, whilst the metal is molten, it not only becomes different in structure from the industrially rolled and formed metal, it becomes vulnerable to contamination from the air (aluminium oxide and dust) the surroundings and added filler materials.



Although the number of weld joins from the first piece was greatly reduced in the second, the number of mechanical joins increased dramatically. This became too time-consuming, and made this piece also unresolved.

This object has a very mechanical look in its appearance and construction. The tall legs are machined, very exacting and bolted to the main form. The lid is monolithic in its angular and solid appearance.



The lid is also perforated on the inside, giving it a mass-produced look. This perforation or drilling reduces the weight of the lid without making it look lighter. Contrasting this machine look is the use of organic forms emerging in the parabolic body and the curved handle. The body is cradled between 3 legs giving the teapot an anthropomorphic look. The colours chosen accentuate the functions of each element. The legs are solid purple to give them visual strength.

The body is light yellow to present a feeling of weightlessness. The lid is a light blue to separate its function with colour.

As a utilitarian object, the teapot functions successfully . After this piece it made sense to change by designs again to suit the material more appropriately. At this stage all welding joins occurred in areas that were well visible

- on the spout at the front of the teapot
- around the rims of the body

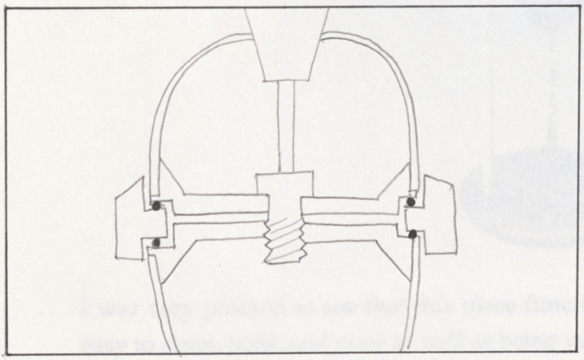
Solutions included :

1 Changing designs so that all welding joins (were) are hidden
2 Masking off weld joins during the anodizing process to hide imperfections
3 Making the welding line a feature

3.3 COFFEE POT NUMBER 1

This piece takes on the notion of hiding all weld joins. It is a continuation of ideas explored previously in form but concentrates specifically in a method of production that is quick and effective.

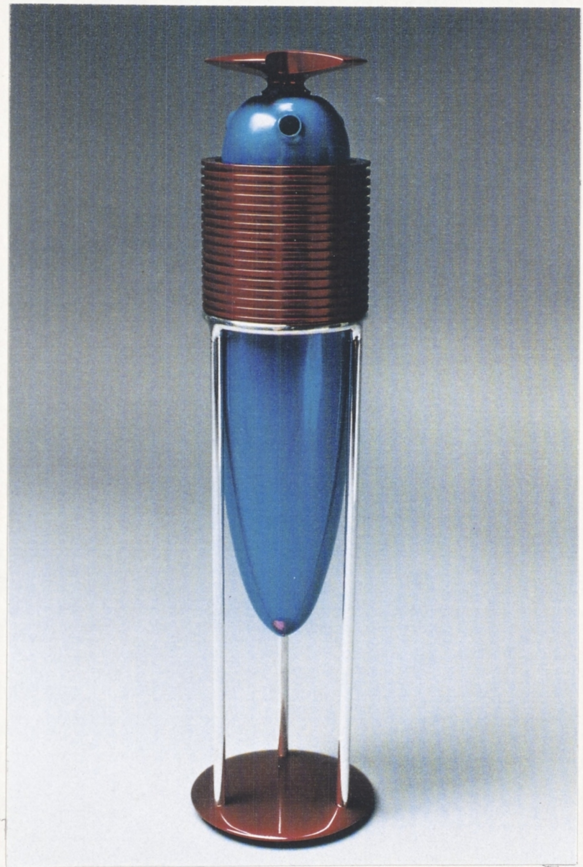
All welding joins are well hidden by a collar, and due to the easy access of the welding nozzle, relatively neat. To avoid problems of welding a spout, a hole was drilled out of the main form and pushed out into the correct shape.



The vessel consists of three main sections, all of which are held together with one bolt and sealed with two Rubber 'o'Rings. The lid is held to the vessel with a morse-taper and threaded bolt which attaches to the main bolt. The piece sits vertically in a tall ring stand.

3.4 COFFEE POT NUMBER 2.

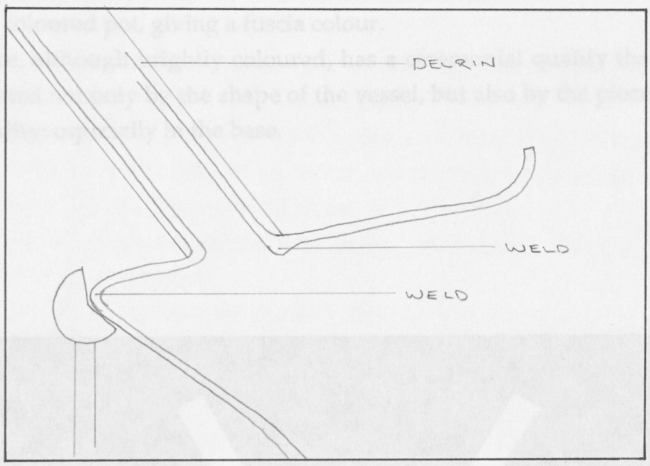
On deciding that the previous piece was successful in most aspects, I decided to continue with the construction techniques involved whilst solving aesthetic problems. This piece consists of two main vessel parts held together by a collar and bolt. However, this time the collar not only acts as a device to hold the two vessel bodies together, but becomes the 'handle' of the piece. The addition of three spouts allows the piece to be picked up from any side. It was also decided that this piece should have a stand which was heavier and more steady than the previous one.



I was very pleased to see that this piece functioned very well in its utility. It is easy to clean, hold, and pour as well as being very stable within its base. Visually, it holds the same dichotomy as in the previous pieces. Man-made/Machine made, machine aesthetic, organic aesthetic, traditional it is function, modern in its style. The piece has a humorous bomb-like appearance which, accentuated by very electric colours, gives it an appearance which demands one's attention.

3.5 TEAPOT NUMBER 3.

On the completion of the second coffee pot, I realized that I had come to a method of construction that was in many ways successful but also led to designs being repetitious and relying more on the construction technique rather than creativity of form. I then decided to make a teapot which would necessitate new ways of concealing weld joins and of assemblage.



The teapot is constructed of 8 pieces, 4 of which are welded together. The simplicity of the piece allowed for minimalization of weld joins, functionality and visual strength.

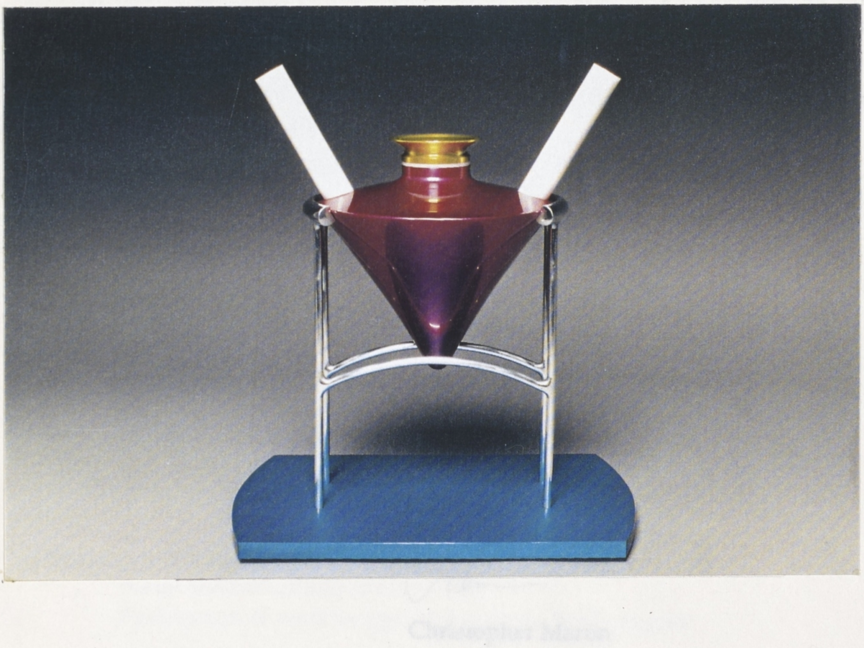
The form, being pointed at the base, required a stand. The stand consists of a flat base, four main uprights, two cross-members and two supports. Originally the stand was designed to conceal the weld join between the two main sections by supporting the piece along this area. Upon construction the stand looked too bulky and it was decided that rather than concealing the join with a ring, it would be better to make the weld a feature by filing it back to base metal. After anodizing however, it became apparent that the weld join did not need to be filed and was left in this state.

In terms of function, the teapot is mostly successful. The 'handle-spouts' are well insulated with delrin sleeves and also where the lid comes into contact with the pot there is a delrin plug which insulates. Rather than screwing off the lids as in the previous two vessels, the lid simply lifts off the pot.

The teapot features two handles which also function as spouts. This dramatically challenges traditional teapot design; allowing change in the visual appearence also.

Visually the teapot works well. The addition of white delrin sleeves on the spout accentuates the other colours. The stand-base reflects blue into the underside of the rose coloured pot, giving a fuscia colour.

The piece, although brightly coloured, has a ceremonial quality that I believe is accentuated not only by the shape of the vessel, but also by the piece's symmetry and solidity; especially in the base.



4 CONCLUSION

It is maybe a dream that form and function go hand in hand. It is a complex balance which often means that to succeed in one, the other must be compromised.I have come close on occasions, and believe that I will come closer still. They work yes, . . .but be careful, they are precious.

This year has been one of success and failure. There were times when I thought " forget it. . . Aluminium . . . just leave it alone. "
However, aluminium offered me too many opportunities with teapot design to give up with technical difficulties. What was needed, was a scientific viewpoint. The more I failed, the more I could learn.
In the end, technique combined with design, so that now, I feel confident that I have achieved a great deal.
There exists a compromise for the user, but... it does insulate, pour, contain, seal, and stand. The simple fact that it is a precious item means that it is limited in its uses. And how well does it work? Well I won't be making tea in it every day.
Though, who would have imagined that a teapot could be constructed in this manner or actually work in this way?
Who could have imagined that a teapot would look like that.

Christopher Maron

Christopher Maron

Born 1969, Canberra, ACT

Education

1992	Commenced Graduate Diploma of Art Canberra School of Art, Institute of the Arts, ANU
1992	Participant in cutlery workshop with Franz-Joseph Bette
1988-91	Bachelor of Arts (Visual) Canberra School of Art, Institute of the Arts, ANU
1990	Participant in the " Künzli Event " workshop

Group Exhibitions

1992	10th Silversmithing Triennale Hanau, Germany Vienna, Austria Schönhoven, Holland
1992	JMGA Graduate Silversmithing Biennial Perth, Australia
1992	Group Silversmithing show Crawford Street Gallery, Sydney
1991	AlFeNiCuZnAgAu, Graduate Silversmithing Exhibition High Court of Australia, ACT
1991	Double or Nothing, Graduate Exhibition Canberra School of Art Gallery, Institute of the Arts, ANU

Publications

1992	Catalogue JMGA Graduate Silversmithing Biennial Perth, Australia
1991	Catalogue Double or Nothing, Graduate Exhibition Canberra School of Art Gallery, Institute of the Arts, ANU
1991	' Learning Collage,Art School led by creative commitment ' Kuala Lumpur Malay Mail, July 10
1991	Photograph of work in Design Ink, Issue No.5, August

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4.4 Appendix Number 1

Tungsten Electrode Operating Ranges.

	AC Welding Current (amps)	
Electrode diameter (in)	Pure and Thoriated Tungsten	Zirconated
1/16	Min to 65	Min to 70
3/32	65 to 150	65 to 160
1/8	100 to 200	100 to 220
5/32	150 to 230	150 to 250
3/16	175 to 275	175 to 300
1/4	275 to 390	275 to 420

4.5 Appendix Number 2

Filler Alloy Selection Guide for TIG and MIG Welding

		PARENT ALLOYS: B6351 C6051 A6061			B6063 B6101			B5083			A5086			A5454			C5154			C5152 A5052			A5005 D5050			Alclad A3004				D3005 A3004				Alclad A3003			A3203 A3003			B1200 A1100		
PARENT ALLOYS	Weld Property	Filler Alloy: B4043	5554	B5356	B4043	5554	B5356	B4043	5554	B5356	B4043	5554	B5356	B4043	5554	B5356	B4043	5554	B5356	B4043	5554	B5356	A1100	B4043	B5356	A1100	B4043	5554	B5356	A1100	B4043	5554	B5356	A1100	B4043	B5356	A1100	B4043	B5356	A1100	B4043	B5356
A1100 B1200	W	A		B	A		B																B	A	B	C	A		B	C	A		B	A	A	B	A	A	B	B	A	C
	S	A		A	A		A																B	A	A	B	A		A	B	A		A	B	A	A	B	A	A	B	A	A
	C	A			A																		A	A		A	A		B	A	A			A	A	B	A	A		A	A	
	T	A			A																		A	A		A	A			A	A			A	A		A	A		A	A	
	M			A			A																A		B	A			B	A			B	A		B	A		B	A		B
	D	C		A	C		A																A	D	B	A	D		B	A	D		B	A	D	B	A	D	B	A	D	B
A3003 A3203	W	A		B	A		B	A		A	A		A	A	C	B	A	C	B	A		B	B	A	B		A		B		A		B	A	A	B	A	A	B			
	S	B		A	B		A	B		A	B		A	B	B	A	B	B	A	B		A	C	B	A		B		A		B		A	C	B	A	C	B	A			
	C	A			A			B		A	B		A	C	A	B	C	A	B	A			A	A			A		B		A			A	A	B	A	A				
	T	A			A									A	A					A			A	A			A				A			A	A		A	A				
	M			A			A			A			A		A	A		A	A			A	A		B				A				A	A		B	A		B			
	D	C		A	C		A	C		A	C		A	C	A	A	C	A	A	C		A	A	D	B		C		A		C		A	A	D	B	A	D	B			
Alclad A3003	W	A		B	A		B	A		A	A		A	A	C	B	A	C	B	A		B	B	A	B		A		B		A		B	A	A	B						
	S	B		A	B		A	B		A	B		A	B	B	A	B	B	A	B		A	C	B	A		B		A		B		A	C	B	A						
	C	A		B	A		B	B		A	B		A	C	A	B	C	A	B	A		B	A	A	B		A		B		A		B	A	A	B						
	T	A			A									A	A					A			A	A			A				A			A	A							
	M			A			A			A			A		A	A		A	A			A	A		B				A				A	A		B						
	D	C		A	C		A	C		A	C		A	C	A	A	C	A	A	C		A	A	D	B		C		A		C		A	A	D	B						
A3004 D3005	W	A		B	A		B	A		A	A		A	A	C	B	A	C	B	A		B		A	B		A	C	B		A	C	B									
	S	C		B	C		B	C		B	C		B	C	C	B	C	C	B	C		B		B	A		C	C	B		C	C	B									
	C	A			A			B		A	B		A	C	A	B	C	A	B	A				A			A	B	C		A	B										
	T	A			A									A	A					A				A			A	A			A	A										
	M			A			A			A			A		A	A		A	A			A			A			A	A			A	A									
	D	C		A	C		A	C		A	C		A	C	A	A	C	A	A	C		A		C	A		C	A	A		C	A	A									
Alclad A3004	W	A		B	A		B	A		A	A		A	A	C	B	A	C	B	A		B		A	B		A	C	B													
	S	C		B	C		B	C		B	C		B	C	C	B	C	C	B	C		B		B	A		C	C	B													
	C	A		B	A		B	B		A	B		A	C	A	B	C	A	B	A		B		A	B		A	B	C													
	T	A			A									A	A					A				A			A	A														
	M			A			A			A			A		A	A		A	A			A			A			A	A													
	D	C		A	C		A	C		A	C		A	C	A	A	C	A	A	C		A		C	A		C	A	A													
A5005 D5050	W	A		B	A		B	A		A	A		A	A	C	B	A	C	B	A		B	C	A	B																	
	S	B		A	B		A	B		A	B		A	B	B	A	B	B	A	B		A		B	A																	
	C	A			A			B		A	B		A	C	A	B	C	A	P	A			A	A																		
	T	A			A									A	A					A			A	A																		
	M			A			A			A			A		A	A		A	A			A	A		B																	
	D	C		A	C		A	C		A	C		A	C	A	A	C	A	A	C		A	A	D	B																	
A5052 C5152	W	A	C	B	A	C	B			A			A	A	C	A	A	C	A	A	C	A																				
	S	C	C	B	B	B	A			B			B	C	C	B	C	C	B	C	C	B																				
	C	A	B		A	B				A			A	C	A	B	C	A	B	B	B																					
	T	A	A		A	A								A	A					A	B																					
	M		B	A		A	A			A			A		A	A		B	A		B	A																				
	D	C	A	A	C	A	A			A			A	C	A	A	C	A	A	C	A	A																				
C5154	W	A	C	B	A	C	B		B	A		B	A		B	B		B	A																							
	S	C	C	B	B	B	A		C	B		C	B		C	B		C	B																							
	C	A	B		A	B			A	A		A	A		A	B		A																								
	T																																									
	M		B	A		A	A		A	A		A	A		A	A		B	A																							
	D	C	A	A	C	A	A		A	A		A	A		A	A		A	A																							
A5454	W	A	C	B	A	C	B		B	A		B	A		B	A																										
	S	C	C	B	B	B	A		C	B		C	B		C	B																										
	C	B	A		B	A			A	B		A	B		A	B																										
	T	A	A		A	A									A																											
	M		A	A		A	A		A	A		A	A		A	A																										
	D	C	A	A	C	A	A		A	A		A	A		A	A																										
A5086	W	A	B	A	A	B	A			A																																
	S	C	C	B	B	B	A			B																																
	C	A	A	A	A	A	A			A																																
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	M		A	A		A	A			A																																
	D	C	A	A	C	A	A			A																																
B5083	W	A	B	A	A	B	A			A																																
	S	C	C	B	B	B	A																																			
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	D	C	A	A	C	A	A			A																																
B6063 B6101	W	A	C	B	A	C	B																																			
	S	B	B	A	B	B	A																																			
	C	A	B	C	A	B	C																																			
	T	A	B		A	B																																				
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A6061 B6351 C6051	W	A	C	B																																						
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	M		B	A																																						
	D	C	A	A																																						

Filler alloys are rated on the following properties:

Symbol	Property
W	Ease of welding
S	Strength of welded joint (as-welded) (Rating applies to fillet welds. All filler alloys rated will develop minimum strength in butt welds)
C	Corrosion resistance in continuous or alternate immersion in fresh or salt water
T	Suitable for service at sustained temperatures above 65 °C
M	Colour match after anodising
D	Ductility (based on free bend elongation)

Notes:

1 A, B, C, and D are relative ratings in decreasing order of merit

2 Alloy combinations with no rating are not recommended